ment is given in detail in the paper, and is made clear by means of diagrams.

M. Daymard's paper was of a commercial rather than a scientific interest. We all recognise that our tonnage laws are anomalous. Unfortunately they have become so interwoven with our commercial system, that it would require nothing less than a revolution to reduce them to a common-sense standard. M. Daymard commands our admiration by his courageous attempt, but as was shown during the discussion, the new laws he proposes, however unexceptionable from a scientific standpoint, would introduce undesirable features. As indicated by the title, he proposes to take the whole external volume of a ship in estimating her tonnage and load-line as well as stability. This seems reasonable, but as an illustration of the undesirability of such a law, it may be pointed out that the tendency of the ship designer working for commercial ends, as all designers of mercantile vessels must do, would be to stint engine accommodation to the manifest danger and discomfort of the engineering staff. The subject, is, however, one which we need not pursue.

Mr. Martell's contribution was one full of information and instruction to the designer of light draught vessels. Its value consisted chiefly in the thirteen plates of illustration containing details of construction of a large number of vessels designed for shallow water navigation. The descriptions which accompanied the illustrations were also of great practical information.

M. Sigaudy's paper, on coupling boilers of different systems, was a brief but instructive contribution. The introduction of the water-tube boiler, which may be said now to be complete in the case of small and exceedingly fast war vessels, appears likely to make headway even in craft not of this special description. The water-tube boiler is, however, something new, and the average engineer, engaged in practical work, always shies at novelties. That is but natural, and it is the result of common sense that caution should be observed when risks have to be run. By the system advocated by M. Sigaudy, the risk is reduced to the smallest dimensions. In a tug-boat built by his Company, an ordinary return tube marine boiler is combined with two water-tube boilers. The engineers of the vessel have therefore a steam generator at their disposal, which they thoroughly understand, and which is sufficient to supply steam to drive the boat at moderate speed. Should the water-tube boilers fail, therefore, they would not be left helpless. One advantage of the water-tube boilers is that steam can be raised very quickly, and this is a very desirable feature in a tug which has at times to be used in cases of emergency. The time occupied upon two trials in raising steam was respectively 22 and 23 minutes. The consumption of fuel was 1·78 lbs. per horse-power per hour, which, it need hardly be said, is a very satisfactory result. No trouble has been found, since the tug has been used, to arise from the combination of the two systems of boilers. In the discussion which followed the reading of this paper, Mr. Yarrow stated that a similar system has been adopted by the Dutch Government in some cruisers they are having built. These vessels are naturally of much larger size than the tug-boat described by M. Sigaudy, and their trials will be looked forward to with considerable interest by the naval world.

Dr. Elgar's paper, on the cost of war-ships, constituted a new departure in the annals of the Institution. It has generally been considered, if not expressly stated, that financial questions are tabooed by the Institution. In the case of Government vessels, doubtless more latitude should be allowed, but in any event it is a difficult thing to exclude money considerations from discussions on subjects which have a commercial basis. After all, ships are built to earn money, and even the designer of war-ships has to keep the question of cost incessantly before him. It would be useless, for instance, suggesting a new form of marine engine, however perfect from a scientific point of view or economical in its working, if its first cost were to be prohibitive. In the discussion which followed the reading of the paper, views similar to these were expressed by prominent members of the Institution, and it is probable that more latitude will be given for the future in this respect. For our own part, it will be impossible to abstract, in anything like reasonable space, the vast quantities of figures given by the author of the paper. His analysis of the subject was very complete, and it may be stated, briefly, led to the happy conclusion that dockyard-built war vessels are costing less than they did of old, relatively to the work put into them. It may be stated, although Dr. Elgar failed to point the fact out in his paper, that this happy state of affairs is largely due to the good work he himself did when Director of Dockyards.

The last two papers of the meeting were on the subject of the hour, water-tube boilers. M. Normand, the well-known builder of torpedo boats at Havre, and one of the most scientific and best informed marine engineers of the day, gave a very valuable analysis of the points which should be observed in designing a water-tube boiler. Naturally, circulation occupied his chief attention, and it may be said briefly that if sufficient activity of circulation of water and steam in the boiler can be maintained, that boiler is likely to be an efficient steam generator. How to obtain such circulation is a complex and disputed question, and here we find our own great authority on the subject, Mr. Thornycroft, at issue with the author of the paper. Mr. Thornycroft, as is well known, is a strong advocate of above water discharge into the steam drum. M. Normand, on the other hand, upholds "drowned" tubes. The subject is a large one, far too large for discussion in a report of this nature. To us it appears that M. Normand is not warranted in all the assumptions upon which he bases his conclusion, and further it may be said that Mr. Thornycroft has experimental data on his side in maintaining that the circulation of water is more active with above water discharge than with drowned tubes. Whether with the latter the circulation is sufficiently active for all practical purposes is of course another matter, the bearing of which it remains for practical experience to prove. For, like the problem M. Bertin attacked in his paper, it is not solvable by theoretical analysis.

Mr. Mark Robinson, in his paper, described a very promising form of water-tube boiler which has been introduced in France by M. Niclausse, the inventor. Without illustrations it would be utterly impossible to make the design clear; but it may be said that the principle followed is that of the Field tube, in which circulation is promoted by means of a pipe inside and coaxial with the heating tube. Curiously enough, however, the tubes in the Niclausse boiler are horizontal, or approximately horizontal, so that the circulation is maintained in the "header" which is divided by a diaphragm, the difference between the specific gravities of the water, or water and steam, contained on each side of the diaphragm causing the movement of the water. This boiler appears to be one of great promise amongst water-tube boilers in situations where the highest evaporative efficiency is not required. It is, however, in these positions that the ordinary return tube boiler is strongest. Whether it will be supplanted by a water-tube boiler remains to be seen; but should such be the case, the Niclausse boiler has the appearance of being a formidable competitor.

No account of the Paris meeting would be complete without reference being made to the beautiful series of photographs shown by M. Bertin in illustration of the movements of ships in a sea-wave. These photographs were taken by the method devised by M. Marey, to which reference has already been made in these columns. A dozen or more different views are given of a ship during its passage through a wave, and the whole movement can thus be fixed and analysed. The value of such data to the naval architect is, of course, immense. In connection with these photographs, which were shown on the screen, there were also exhibited some very beautiful projections of photographs in colours. These were shown by M. Charles Comte, one of M. Marey's assistants. The subject is one which has been attracting attention of late, and has been referred to elsewhere in these columns.

METEOROLOGICAL PROBLEMS FOR PHYSICAL LABORATORIES.

In response to several requests from both teachers and students for suggestions as to problems that can be taken up in physical laboratories, Prof. Cleveland Abbe gives the following list of subjects, in the *American Meteorological Journal* for May. The initialled subjects are due to Prof. C. F. Marvin.

SUBJECTS FOR EXPERIMENTAL INVESTIGATION.

(1) The internal sensitiveness of thermometers, or the length of time required to bring the top of the thermometer column to the proper reading when the external surface of bulb and stem is kept at a constant temperature below, or above, some initial temperature.

(2) The influence of the wind on the pressure within a room, or other closed space, containing a barometer.

(3) The influence of the condition of any surface (as to

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chemical nature, cleanness, and dust) upon the deposition of dew and the determination of the dew-point.

(4) The behaviour of the wet-bulb thermometer, when covered with water, in an atmosphere of water vapour and of ice vapour.

(5) The influence of radiant heat on wet bulbs covered with ice or water.

(6) The increase of the reading of the wet-bulb thermometer due to any compression that may result from the formation of the ice film on the muslin covering; its dependence on the muslin rather than on the ice.

(7) The determination of the tension of water vapour and ice vapour at and below freezing.

(8) The rate of diffusion of ice vapour as distinguished from aqueous vapour, and also the rates of evaporation from ice and water at the same temperature.

(9) The condensation of vapour in a region free from solid nuclei, and after the temperature has been reduced to, or below, the point of saturation so that the vapour is in a state of unstable equilibrium.

(10) The change that can be produced in the pressure and temperature of a confined volume of *dust free* "dry saturated" steam or other vapour by the introduction of dust particles having various chemical and physical properties. This is the secret of the action of the "cloud engine" of Montgomery J. Storms.

(11) Invention of improved and practical methods of obtaining the moisture contents of the air—especially at low temperatures. —C. F. M.

(12) Invention of recording thermometers, barometers, and hygrometers adapted by their accuracy, their extreme lightness, and the quickness with which they respond to atmospheric changes, to be carried up by balloons and by kites in investigations into the condition of the higher atmosphere.—C. F. M.

(13) The development and perfecting of the art of constructing and flying kites with a view of rendering this practically applicable in investigations of the condition of the atmosphere at moderate elevations.—C. F. M.

(14) Invention of improved and practical devices for the registration of sunshine and cloudiness, both day and night.—C. F. M.

(15) Invention of devices recording exactly the beginnings and endings, amounts and rates, of precipitation, &c.—C. F. M.

(16) Explanation of the formation of ice-needles in gravelly soil, and determination of the amount of heat and moisture retained at the earth's surface by this formation.

(17) Explanation of the origin of the hollow tubes in the ice-needles and the similar hollow tubes in snow crystals and the analogous holes in hailstones.

(18) The connection between atmospheric conditions and the formation of snow crystals of different shapes and sizes.

(19) The radiating and conducting powers of layers of snow freshly fallen or old and granulated.

(20) The radiation and absorption of heat by dustless, dry air, and also by ordinary atmospheric air containing dust and vapour or ice particles.

(21) Investigation of the formula for computing the velocity and the pressure of the wind from various forms of anemometers, especially the whirling, the pressure, and the suction anemometers.

(22) Invention of the most convenient and cheapest form of nephoscope for determining either direction or velocity, or both these elements of the motion of the clouds.

(23) Investigation of the correction to be made to the record of the ordinary cylindrical rain and snow gauge for the effect of the wind in drifting the rain, and especially the snow

(24) Study of the temperature of the soil at different depths from the surface-layer down to three feet and under different conditions, as to moisture-content, sunshine, and wind.

(25) Invention of better methods of determining at any moment the temperature and moisture at any depth in the soil.

(26) Determination of the quantity of water evaporated from natural surfaces, especially ocean water, ice or snow, fresh water, and forests or cultivated fields, and its relation to humidity, temperature, and wind.

(27) Improvements in the actinometer and a series of determinations of the amounts of heat received at any point, both from the sun directly and from the clouds and the atmosphere by reflection or radiation.

(28) Observations of the polarisation and the intensity of blue sky light and comparison with optical theories.

(29) Instrumental methods for recording some of the various chemical effects directly produced by solar radiation, and which are of special importance in the growth of plants, the decomposition of the soil, and the purification of water.

(30) A series of determinations or, still better, a continuous record of the simultaneous differences of electric potential between the earth's surface, and several points in the free atmosphere, one hundred feet apart, vertically, meridionally, and prime-vertically.

(31) A similar series for several points beneath the earth's surface as to their electro-magnetic condition, and a correlation of the distribution of electric conditions with the electric currents in the air and the earth.

(32) A study of the scintillation of the stars and its relation to atmospheric conditions.

(33) A study of the apparent acoustic opacity of the atmosphere at certain places and times.

(34) An explanation of the sounds attending large aerolites, and an explanation as to what may be learned therefrom regarding the upper atmosphere and in regard to the improvement of fog signals.

(35) A study of the formation of halos, parhelia, and corona, by the action of snow crystals and water-drops on sunlight.

(36) Investigation of the first step in the process of convection, as it occurs in the free atmosphere by which small currents of warm air, rising as slender rolls and whirls, mix with the cooler air, and are broken up within a few feet of the earth's surface; a determination of the limit at which such convection becomes inappreciable.

(37) A study of the larger convection currents, their relation to the horizontal motion, the extent to which they retard and accelerate the motions or increase and decrease the pressures in the upper and lower strata.

THE SENSES OF INSECTS.[1]

Of the five ordinary senses recognised in ourselves and most higher animals, insects have, beyond all doubt, the sense of sight, and there can be as little question that they possess the senses of touch, taste, smell, and hearing. Yet, save perhaps that of touch, none of these senses, as possessed by insects, can be strictly compared with our own, while there is the best of evidence that insects possess other senses which we do not, and that they have sense organs with which we have none to compare. He who tries to comprehend the mechanism of our own senses—the manner in which the subtler sensations are conveyed to the brain—will realise how little we know thereof after all that has been written. It is not to be wondered at, therefore, that authors should differ as to the nature of many of the sense organs of insects, or that there should be little or no absolute knowledge of the manner in which the senses act upon them. The solution of psychical problems may never, indeed, be obtained, so infinitely minute are the ultimate atoms of matter; and those who have given most attention to the subject must echo the sentiment of Lubbock, that the principal impression which the more recent works on the intelligence and senses of animals leave on the mind is that we know very little, indeed, on the subject. We can but empirically observe and experiment and draw conclusions from well attested results.

Sight.—Taking first the sense of sight, much has been written as to the picture which the compound eye of insects produces upon the brain or upon the nerve centres. Most insects which undergo complete metamorphoses possess in their adolescent states simple eyes or ocelli, and sometimes groups of them of varying size and in varying situations. It is difficult, if not impossible, to demonstrate experimentally their efficiency as organs of sight; the probabilities are that they give but the faintest impressions, but otherwise act as do our own. The fact that they are possessed only by larvæ which are exposed more or less fully to the light, while those larvæ which are endophytous, or otherwise hidden from light, generally lack them, is in itself proof that they perform the ordinary functions of sight, however low in degree. In the imago state the great majority of insects have their simple eyes in addition to the compound eyes. In many cases, however, the former are more or less covered with vestiture, which is another evidence that their function is of a low

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[1] From an address on "Social Insects," delivered by Prof. C. V. Riley, as President of the Biological Society of Washington (Reprinted (slightly condensed) from *Insect Life*, vol. vii. No. 1.")

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